Syllabus and Scheme of Examination
B.Sc. (General/Program) with Chemistry

Prepared by
UGBOS (Chemistry)

4. Generic Elective Papers for B.Sc. (Honors) with subjects other than Chemistry

Course	Course Name	Credit
Generic Elective-1	CHEMGT-1 + CHEMGP-1	4+2
Generic Elective-II	CHEMGT-2 + CHEMGP-2	4+2
Generic Elective- III	CHEMGT-3 + CHEMGP-3	4+2
Generic Elective-IV	CHEMGT-4 + CHEMGP-4	4+2

Details of syllabi are given below in Section 7.

5. Course wise Credit Distribution in B.Sc. (General) with Science

Course	Total no of Papers	Credit			
		Theory		Practical	
		Per paper	Total	Per paper	Total
Core Courses	12	4	4 x 12=48	2	2x12=24
Discipline Specific Elective	6	4	4x6=24	2	2x6=12
Ability Enhancement (Language)	2	2	2x2 = 4	-	-
Skill Enhancement	4	2	2x4 = 8	-	-
Total	24	NA	84	NA	36

6. Semester wise CBCS curricula (Courses, course names, broad area, credit and marks) for B.Sc. (General) with Science

Semester	Course	Course Name	Broad area	Credit
I	Core Course-1 (Theory)	CHEMGT-1	Chemistry 1A	4
	Core Course-1 (Practical)	CHEMGP-1	Chemistry 1A	2
	Core Course-2 (Theory)	TBD	TBD	4
	Core Course-2 (Practical)	TBD	TBD	2
	Core Course-3 (Theory)	TBD	TBD	4
	Core Course-3 (Practical)	TBD	TBD	2
	Ability Enhancement Compulsory Course - 1	TBD	English communication / Environmental Science	2
II	Core Course-4 (Theory)	CHEMGT-2	Chemistry – 1B	4
	Core Course-4 (Practical)	CHEMGP-2	Chemistry – 1B	2
	Core Course-5 (Theory)	TBD	TBD	4
	Core Course-5 (Practical)	TBD	TBD	2
	Core Course-6 (Theory)	TBD	TBD	4
	Core Course-6 (Practical)	TBD	TBD	2
	Ability Enhancement Compulsory Course - 2	TBD	English communication / Environmental Science	2
III	Core Course-7 (Theory)	CHEMGT-3	Chemistry – 1C	4
	Core Course-7 (Practical)	CHEMGP-3	Chemistry – 1C	2
	Core Course-8 (Theory)	TBD	TBD	4
	Core Course-8 (Practical)	TBD	TBD	2
	Core Course-9 (Theory)	TBD	TBD	4
	Core Course-9 (Practical)	TBD	TBD	2
	Skill enhancement** Course - 1	TBD	TBD	2
IV	Core Course-10 (Theory)	CHEMGT-4	Chemistry – 1D	4
	Core Course-10(Practical)	CHEMGP-4	Chemistry – 1D	2
	Core Course-11(Theory)	TBD	TBD	4
	Core Course-11(Practical)	TBD	TBD	2
	Core Course-12(Theory)	TBD	TBD	4
	Core Course-12(Practical)	TBD	TBD	2
	Skill enhancement Course - 2	TBD	TBD	2

V	Discipline Specific* Elective-1 (Theory)	To be chosen from pool of courses		4
	Discipline Specific Elective-1 (Practical)			2
	Discipline Specific Elective-2 (Theory)	To be chosen from pool of courses		4
	Discipline Specific Elective-2 (Practical)			2
	Discipline Specific Elective-3 (Theory)	To be chosen from pool of courses		4
	Discipline Specific Elective-3 (Practical)			2
	Skill enhancement Course - 3	To be chosen from pool of courses		2
VI	Discipline Specific Elective-4 (Theory)	To be chosen from pool of courses		4
	Discipline Specific Elective-4 (Practical)			2
	Discipline Specific Elective-5 (Theory)	To be chosen from pool of courses		4
	Discipline Specific Elective-5 (Practical)			2
	Discipline Specific Elective-6 (Theory)	To be chosen from pool of courses		4
	Discipline Specific Elective-6 (Practical)			2
	Skill enhancement Course - 4	TBD	TBD	2

* Pool of Discipline specific Electives from Chemistry:

CHEMHTDSE-1A + CHEMHPDSE-1A	Polymer Chemistry
CHEMHTDSE-1B + CHEMHPDSE-1B	Inorganic Materials of Industrial Importance
CHEMHTDSE-2A + CHEMHPDSE-2A	Analytical Methods in Chemistry
CHEMHTDSE-2B + CHEMHPDSE-2B	Instrumental Methods of Chemical Analysis
CHEMHTDSE-2C + CHEMHPDSE-2C	Green Chemistry

** Pool of skill enhancement courses from Chemistry:

CHEMHS – 1A	IT skills for Chemist
CHEMHS-1B	Basic Analytical Chemistry
CHEMHS – 2A	Pharmaceutical Chemistry
CHEMHS - 2B	Analytical clinical Biochemistry

7. Chemistry Syllabi of B.Sc.(General) with Science

Semester - I

CHEMGT-1	Theory: Atomic Structure,Chemical Periodicity, Acids and Bases,Redox Reactions,General Organic Chemistry & Aliphatic Hydrocarbons	4 Credit

Inorganic Chemistry - I

1. Atomic Structure **(9L)**

Bohr's theory for hydrogen atom (simple mathematical treatment), atomic spectra of hydrogen and Bohr's model, Sommerfeld's model, quantum numbers and their significance, Pauli's exclusion principle, Hund's rule, electronic configuration of many-electron atoms, Aufbau principle and its limitations.

2. Chemical Periodicity **(9L)**

Classification of elements on the basis of electronic configuration: general characteristics of s-, p-, d- and f-block elements. Positions of hydrogen and noble gases in the periodic table. Atomic and ionic radii, ionization potential, electron affinity, and electronegativity; periodic and group-wise variation of above properties in respect of s- and p- block elements.

3. Acids and bases **(8L)**

Brönsted–Lowry concept, conjugate acids and bases, relative strengths of acids and bases, effects of substituent and solvent, differentiating and levelling solvents. Lewis acid-base concept, classification of Lewis acids and bases, Lux-Flood concept and solvent system concept. Hard and soft acids and bases (HSAB concept), applications of HSAB process.

4. Redox reactions **(4L)**

Balancing of equations by oxidation number and ion-electron method, Standard electrode potential, formal potential, redox indicator and redox titrations.

Organic Chemistry – I

1.Fundamentals of Organic Chemistry **(5L)**

Electronic displacements: Inductive effect, resonance and hyperconjugation; cleavage of bonds: homolytic and heterolytic; structure of organic molecules on the basis of VBT; nucleophiles and electrophiles; reactive intermediates: carbocations, carbanions and free radicals.

2. Stereochemistry **(5L)**

Different types of isomerism; geometrical and optical isomerism; concept of chirality and optical activity (up to two carbon atoms); asymmetric carbon atom; elements of symmetry (plane and centre); interconversion of Fischer and Newman representations; enantiomerism and diastereomerism, meso compounds; threo and erythro, D and L, cis and trans nomenclature; CIP Rules: R/S (upto 2 chiral carbon atoms) and E/Z nomenclature.

3. Nucleophilic Substitution and Elimination Reactions **(4L)**

Nucleophilic substitutions: S_N1 and S_N2 reactions; eliminations: E1 and E2 reactions (elementary mechanistic aspects); Saytzeff and Hofmann eliminations; elimination vs substitution.

4. Aliphatic Hydrocarbons **(12L)**

Functional group approach for the following reactions (preparations & reactions) to be studied in context to their structures.

Alkanes (up to 5 Carbons).

Preparation: catalytic hydrogenation, Wurtz reaction, Kolbe's synthesis, from Grignard reagent. Reactions: mechanism for free radical substitution: halogenation.

Alkenes: (up to 5 Carbons).

Preparation: elimination reactions: dehydration of alcohols and dehydrohalogenation of alkyl halides; cis alkenes (partial catalytic hydrogenation) and trans alkenes (Birch reduction). Reactions: cis-addition (alkaline $KMnO_4$) and trans-addition (bromine) with mechanism, addition of HX [Markownikoff's (with mechanism) and anti-Markownikoff's addition],

hydration, ozonolysis, oxymercuration-demercuration and hydroboration-oxidation reaction.

Alkynes: (up to 5 Carbons).

Preparation: acetylene from CaC_2 and conversion into higher alkynes; by dehalogenation of tetra halides and dehydrohalogenation of vicinal dihalides. Reactions: formation of metal acetylides, addition of bromine and alkaline $KMnO_4$, ozonolysis and oxidation with hot alkaline $KMnO_4$.

Reference Books

1. Lee, J.D. Concise Inorganic Chemistry ELBS, 1991. 2. Cotton, F.A., Wilkinson, G. & Gaus, P.L. Basic Inorganic Chemistry, 3rd ed., Wiley. 3. Douglas, B.E., McDaniel, D.H. & Alexander, J.J. Concepts and Models in Inorganic Chemistry, John Wiley & Sons. 4. Huheey, J.E., Keiter, E.A., Keiter, R.L. & Medhi, O.K. Inorganic Chemistry: Principles of Structure and Reactivity, Pearson Education Ind 5. Sethi, A. Conceptual Organic Chemistry; New Age International Publisher. 6. Parmar, V. S. A Text Book of Organic Chemistry, S. Chand & Sons. 7. Madan, R. L. Organic Chemistry, S. Chand & Sons. 8. Wade, L. G., Singh, M. S., Organic Chemistry. 9. Finar, I. L. Organic Chemistry (Volume 1), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education). 10. Morrison, R. T. & Boyd, R. N. Organic Chemistry, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education). 11. Eliel, E. L. & Wilen, S. H. Stereochemistry of Organic Compounds, Wiley: London, 1994. 12. Sen Gupta, Subrata. Basic Stereochemistry of Organic molecules. 13. Kalsi, P. S. Stereochemistry Conformation and Mechanism, Eighth edition, New Age International, 2014. 14. Bahl, A. & Bahl, B.S. Advanced Organic Chemistry, S. Chand, 2010.

CHEMGP-1	**Practical**	**2 Credit**

Inorganic Chemistry - I

1. Estimation of sodium carbonate and sodium hydrogen carbonate present in a mixture.
2. Estimation of oxalic acid by titrating it with $KMnO_4$.
3. Estimation of water of crystallization in Mohr's salt by titrating with $KMnO_4$.
4. Estimation of Fe (II) ions by titrating it with $K_2Cr_2O_7$.
5. Estimation of Cu (II) ions iodometrically using $Na_2S_2O_3$.

Organic Chemistry – I

Qualitative Analysis of Single Solid Organic Compound(s)

1. Detection of special elements (N, Cl, and S) in organic compounds.
2. Solubility and Classification (solvents: H_2O, dil. HCl, dil. NaOH, dil. $NaHCO_3$)
3. Detection of functional groups: Aromatic-NO_2, Aromatic-NH_2, -COOH, carbonyl (no distinction of –CHO and >C=O needed), -OH (phenolic) in solid organic compounds.

Experiments 1 to 3 with unknown (at least 6) solid samples containing not more than two of the above type of functional groups should be done.

Reference Books

1. University Hand Book of Undergraduate Chemistry Experiments, edited by Mukherjee, G. N., University of Calcutta, 2003. 2. Das, S. C., Chakraborty, S. B., Practical Chemistry. 3. Mukherjee, K. S. Text book on Practical Chemistry, New Oriental Book Agency. 4. Ghosal, Mahapatra & Nad, An Advanced course in practical Chemistry, New Central Book Agency. 5. Vogel, A. I. Elementary Practical Organic Chemistry, Part 2: Qualitative Organic Analysis, CBS Publishers and Distributors. 6. Vogel, A.I., Tatchell, A.R., Furnis, B.S., Hannaford, A.J. & Smith, P.W.G., Textbook of Practical Organic Chemistry, Prentice-Hall, 5th edition, 1996. 7. Mann, F.G. & Saunders, B.C. Practical Organic Chemistry Orient-Longman, 1960.

Semester – II

CHEMGT-2	**Theory: States of Matter & Chemical Kinetics, Chemical Bonding & Molecular Structure, P-Block**	**4 Credit**

	Elements	
Physical Chemistry – I		
1. Kinetic Theory of Gases and Real gases (12L) a. Concept of pressure and temperature; Collision of gas molecules; Collision diameter; Collision number and mean free path; Frequency of binary collisions (similar and different molecules); Rate of effusion b. Nature of distribution of velocities, Maxwell's distribution of speed and kinetic energy; Average velocity, root mean square velocity and most probable velocity; Principle of equipartition of energy and its application to calculate the classical limit of molar heat capacity of gases c. Deviation of gases from ideal behavior; compressibility factor; Boyle temperature; Andrew's and Amagat's plots; van der Waals equation and its features; its derivation and application in explaining real gas behaviour; Existence of critical state, Critical constants in terms of van der Waals constants; Law of corresponding states d. Viscosity of gases and effect of temperature and pressure on coefficient of viscosity (qualitative treatment only) **2. Liquids (5L)** Definition of Surface tension, its dimension and principle of its determination using stalagmometer; Viscosity of a liquid and principle of determination of coefficient of viscosity using Ostwald viscometer; Effect of temperature on surface tension and coefficient of viscosity of a liquid (qualitative treatment only) **3. Solids (5L)** Forms of solids, crystal systems, unit cells, Bravais lattice types, Symmetry elements; Laws of Crystallography - Law of constancy of interfacial angles, Law of rational indices; Miller indices of different planes and interplanar distance, Bragg's law; Structures of NaCl, KCl and CsCl treatment only); Defects in crystals; Glasses and liquid crystals. **4. Chemical Kinetics (8L)** a. Introduction of qualitative rate law, order and molecularity; Extent of reaction; rate constants; Rates of First, second and nth order reactions and their Differential and integrated forms (with derivation); Pseudo first order reactions; Determination of order of a reaction by half-life and differential method; Opposing reactions, consecutive reactions and parallel reactions b. Temperature dependence of rate constant; Arrhenius equation, energy of activation; Collision theory; Lindemann theory of unimolecular reaction; outline of Transition State theory (classical treatment)		
Inorganic Chemistry - II		
1. Chemical Bonding and Molecular Structure (20L) a. Ionic Bonding: General characteristics of ionic bonding. Energy considerations in ionic bonding, lattice energy and solvation energy and their importance in the context of stability and solubility of ionic compounds. Statement of Born-Landé equation for calculation of lattice energy, Born-Haber cycle and its applications, polarizing power and polarizability. Fajan's rules, ionic character in covalent compounds, bond moment, dipole moment and percentage ionic character. b. Covalent bonding: VB Approach: Shapes of some inorganic molecules and ions on the basis of VSEPR and hybridization with suitable examples from s and p block elements of linear, trigonal planar, square planar, tetrahedral, trigonal bipyramidal and octahedral arrangements. c. Concept of resonance and resonating structures in various inorganic and organic compounds. d. MO Approach: Rules for the LCAO method, bonding and antibonding MOs and their characteristics for s-s, s-p and p-p combinations of atomic orbitals, nonbonding combination of orbitals, MO treatment of homonuclear diatomic molecules of 1st and 2nd periods. (including idea of s- p mixing) and heteronuclear diatomic molecules such as CO, NO and NO^+. Comparison of VB and MO approaches. **2. Comparative study of p-block elements (10L)**		

a. Group trends in electronic configuration, modification of pure elements, common oxidation states, inert pair effect, and their important compounds in respect of the following groups of elements:
i. B-Al-Ga-In-Tl
ii. C-Si-Ge-Sn-Pb
iii. N-P-As-Sb-Bi
iv. O-S-Se-Te
v. F-Cl-Br-I

Reference Books

1. Barrow, G.M. Physical Chemistry Tata McGraw-Hill (2007). 2. Castellan, G.W. Physical Chemistry 4th Ed. Narosa (2004). 3. Kotz, J.C., Treichel, P.M. & Townsend, J.R. General Chemistry Cengage Learning India Pvt. Ltd., New Delhi (2009). 4. Mahan, B.H. University Chemistry 3rd Ed. Narosa (1998). 5. Petrucci, R.H. General Chemistry 5th Ed. Macmillan Publishing Co.: New York (1985). 6. Chugh, K.L., Agnish, S.L. A Text Book of Physical Chemistry Kalyani Publishers. 7. Bahl, B.S., Bahl, A., Tuli, G.D., Essentials of Physical Chemistry S. Chand & Co. ltd. 8. Palit, S. R., Elementary Physical Chemistry Book Syndicate Pvt. Ltd. 9. Mandal, A. K. Degree Physical and General Chemistry Sarat Book House. 10. Pahari, S., Physical Chemistry New Central Book Agency. 11. Pahari, S., Pahari, D., Problems in Physical Chemistry New Central Book Agency. 12. Cotton, F.A. & Wilkinson, G. Basic Inorganic Chemistry, Wiley. 13. Shriver, D.F. & Atkins, P.W. Inorganic Chemistry, Oxford University Press. 14. Wulfsberg, G. Inorganic Chemistry, Viva Books Pvt. Ltd. 15. Rodgers, G.E. Inorganic & Solid State Chemistry, Cengage Learning India Ltd., 2008.

CHEMGP-2	Practical:	2 Credit

Physical Chemistry – I

1. Surface tension measurement (use of organic solvents excluded)
a. Determination of the surface tension of a liquid or a dilute solution using a Stalagmometer
b. Study of the variation of surface tension of a detergent solution with concentration
2. Viscosity measurement (use of organic solvents excluded)
a. Determination of the relative and absolute viscosity of a liquid or dilute solution using an Ostwald's viscometer
b. Study of the variation of viscosity of an aqueous solution with concentration of solute
3. Study the kinetics of the following reactions
a. Initial rate method: Iodide-persulphate reaction
b. Integrated rate method:
i. Acid hydrolysis of methyl acetate with hydrochloric acid
ii. Compare the strengths of HCl and H_2SO_4 by studying kinetics of hydrolysis of methyl acetate

Inorganic Chemistry – II

Qualitative semi-micro analysis of mixtures containing three radicals. Emphasis should be given to the understanding of the chemistry of different reactions.
Acid Radicals: Cl^-, Br^-, I^-, NO_2^-, NO_3^-, S^{2-}, SO_4^{2-}, BO_3^{3-}, H_3BO_3.
Basic Radicals: Na^+, K^+, Ca^{2+}, Sr^{2+}, Ba^{2+}, Cr^{3+}, Mn^{2+}, Fe^{3+}, Ni^{2+}, Cu^{2+}, NH_4^+.

Reference Books

1. University Hand Book of Undergraduate Chemistry Experiments, edited by Mukherjee, G. N., University of Calcutta, 2003. 2. Palit, S.R., Practical Physical Chemistry Science Book Agency. 3. Mukherjee, N.G., Selected Experiments in Physical Chemistry J. N. Ghose & Sons. 4. Dutta, S.K., Physical Chemistry Experiments Bharati Book Stall. 5. Svehla, G. Vogel's Qualitative Inorganic Analysis, Pearson Education, 2012. 6. Khosla, B. D.; Garg, V. C. & Gulati, A. Senior Practical Physical Chemistry, R. Chand & Co.: New Delhi (2011).

Semester - III

CHEMGT-3	Theory: Chemical Energetics, Equilibria, Organic Chemistry-II	4 Credit

Physical Chemistry - II

1. Chemical Energetics **(12L)**

a. Intensive and extensive variables; state and path functions; isolated, closed and open systems; zeroth law of thermodynamics; Concept of heat, work, internal energy and statement of first law; enthalpy, H; relation between heat capacities, calculations of q, w, U and H for reversible, irreversible and free expansion of gases

b. Standard states; Heats of reaction; enthalpy of formation of molecules and ions and enthalpy of combustion and its applications; Laws of thermochemistry; bond energy, bond dissociation energy and resonance energy from thermochemical data, Kirchhoff's equations and effect of pressure on enthalpy of reactions; Adiabatic flame temperature; explosion temperature

c. Statement of the second law of thermodynamics; Concept of heat reservoirs and heat engines; Carnot cycle; Physical concept of Entropy; Carnot engine, refrigerator and efficiency; Entropy change of systems and surroundings for various processes and transformations; Auxiliary state functions (G and A) and Criteria for spontaneity and equilibrium.

2. Chemical Equilibrium: **(9L)**

Thermodynamic conditions for equilibrium, degree of advancement; Variation of free energy with degree of advancement; Equilibrium constant and standard Gibbs free energy change; Definitions of K_P, K_C and K_X and relation among them; van't Hoff's reaction isotherm, isobar and isochore from different standard states; Shifting of equilibrium due to change in external parameters e.g. temperature and pressure; variation of equilibrium constant with addition to inert gas; Le Chatelier's principle

3. Ionic Equilibria: **(9L)**

Strong, moderate and weak electrolytes, degree of ionization, factors affecting degree of ionization, ionization constant and ionic product of water; Ionization of weak acids and bases, pH scale, common ion effect; Salt hydrolysis-calculation of hydrolysis constant, degree of hydrolysis and pH for different salts; Buffer solutions; Solubility and solubility product of sparingly soluble salts – applications of solubility product principle

Organic Chemistry - II

Functional group approach for the following reactions (preparations & reactions) to be studied in context to their structures.

1. Aromatic Hydrocarbons **(7L)**

Benzene: Preparation: from phenol, by decarboxylation, from acetylene, from benzene sulphonic acid. Reactions: electrophilic substitution (general mechanism); nitration (with mechanism), halogenations (chlorination and bromination), sulphonation and Friedel-Craft's reaction (alkylation and acylation) (up to 4 carbons on benzene); side chain oxidation of alkyl benzenes (up to 4 carbons on benzene).

2. Organometallic Compounds **(4L)**

Introduction; Grignard reagents: Preparations (from alkyl and aryl halide); concept of umpolung; Reformatsky reaction.

3. Aryl Halides **(4L)**

Preparation: (chloro-, bromo- and iodobenzene): from phenol, Sandmeyer reactions. Reactions (Chlorobenzene): nucleophilic aromatic substitution (replacement by –OH group) and effect of nitro substituent (activated nucleophilic substitution).

4. Alcohols, Phenols and Ethers **(8L)**

a. Alcohols: (up to 5 Carbons). Preparation: 1°-, 2°- and 3°- alcohols: using Grignard reagent, reduction of aldehydes, ketones, carboxylic acid and esters; Reactions: With sodium, HX (Lucas test), oxidation (alkaline $KMnO_4$, acidic dichromate, concentrated HNO_3); Oppenauer oxidation;

b. Diols: Preparation (with OsO_4); pinacol- pinacolone rearrangement (with mechanism) (with symmetrical diols only).

c. Phenols: Preparation: cumene hydroperoxide method, from diazonium salts; acidic nature of

phenols; Reactions: electrophilic substitution: nitration and halogenations; Reimer-Tiemann reaction, Houben–Hoesch condensation, Schotten–Baumann reaction, Fries rearrangement and Claisen rearrangement.

d. Ethers: Preparation: Williamson's ether synthesis; Reaction: cleavage of ethers with HI.

5. Carbonyl Compounds **(7L)**

Aldehydes and Ketones (aliphatic and aromatic): (Formaldehye, acetaldehyde, acetone and benzaldehyde): Preparation: from acid chlorides, from nitriles and from Grignard reagents; general properties of aldehydes and ketones; Reactions: with HCN, ROH, $NaHSO_3$, NH_2-G derivatives and with Tollens' and Fehling's reagents; iodoform test; aldol condensation (with mechanism); Cannizzaro reaction (with mechanism), Wittig reaction, benzoin condensation; Clemmensen reduction, Wolff-Kishner reduction and Meerwein-Pondorff-Verley (MPV) reduction.

Reference Books

1. Barrow, G.M. Physical Chemistry Tata McGraw-Hill (2007). 2. Castellan, G.W. Physical Chemistry 4th Ed. Narosa (2004). 3. Kotz, J.C., Treichel, P.M. & Townsend, J.R. General Chemistry Cengage Learning India Pvt. Ltd., New Delhi (2009). 4. Mahan, B.H. University Chemistry 3rd Ed. Narosa (1998). 5. Ekambaram, S. General Chemistry, Pearson. 6. Petrucci, R.H. General Chemistry 5th Ed. Macmillan Publishing Co.: New York (1985). 8. Chugh, K.L., Agnish, S.L. A Text Book of Physical Chemistry Kalyani Publishers. 9. Bahl, B.S., Bahl, A., Tuli, G.D., Essentials of Physical Chemistry S. Chand & Co. ltd. 10. Palit, S. R., Elementary Physical Chemistry Book Syndicate Pvt. Ltd. 11. Mandal, A. K. Degree Physical and General Chemistry Sarat Book House. 12. Pahari, S., Physical Chemistry New Central Book Agency. 13. Pahari, S., Pahari, D., Problems in Physical Chemistry New Central Book Agency. 14. Sethi, A. Conceptual Organic Chemistry; New Age International Publisher. 15. Parmar, V. S. A Text Book of Organic Chemistry, S. Chand & Sons. 16. Madan, R. L. Organic Chemistry, S. Chand & Sons. 17. Wade, L. G., Singh, M. S., Organic Chemistry, Pearson. 18. Finar, I. L. Organic Chemistry (Volume 1), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education). 19. Morrison, R. T. & Boyd, R. N. Organic Chemistry, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education). 20. Bahl, A. & Bahl, B.S. Advanced Organic Chemistry, S. Chand, 2010.

CHEMGP-3	**Practical**	**2 Credit**

Physical Chemistry - II

(Minimum five experiments to complete)

Thermochemistry

1. Determination of heat capacity of calorimeter for different volumes
2. Determination of enthalpy of neutralization of hydrochloric acid with sodium hydroxide
3. Determination of enthalpy of ionization of acetic acid
4. Determination of enthalpy of hydration of copper sulphate

Ionic Equilibria

1. Measurement of pH of different solutions like aerated drinks, fruit juices, shampoos and soaps (use dilute solutions of soaps and shampoos to prevent damage to the glass electrode) using pH-meter and compare it with the indicator method
2. Preparation of buffer solutions and find the pH of an unknown buffer solution by colour matching method (using following buffers)
   a. Sodium acetate-acetic acid
   b. Ammonium chloride-ammonium hydroxide
3. Study of the solubility of benzoic acid in water.

Organic Chemistry - II

Identification of a pure organic compound

1. Solid compounds: oxalic acid, tartaric acid, succinic acid, resorcinol, urea, glucose, benzoic acid and salicylic acid.
2. Liquid Compounds: methyl alcohol, ethyl alcohol, acetone, aniline, dimethylaniline,

benzaldehyde, chloroform and nitrobenzene

Reference Books

1. University Hand Book of Undergraduate Chemistry Experiments, edited by Mukherjee, G. N., University of Calcutta, 2003. 2. Palit, S.R., Practical Physical Chemistry Science Book Agency. 3. Mukherjee, N.G., Selected Experiments in Physical Chemistry J. N. Ghose & Sons. 4. Dutta, S.K., Physical Chemistry Experiments Bharati Book Stall. 5. Bhattacharyya, R. C, A Manual of Practical Chemistry. 6. Vogel, A.I., Tatchell, A.R., Furnis, B.S., Hannaford, A.J. & Smith, P.W.G., Textbook of Practical Organic Chemistry, Prentice-Hall, 5th edition, 1996. 7. Mann, F.G. & Saunders, B.C. Practical Organic Chemistry Orient-Longman, 1960.

Semester – IV

CHEMGT-4	Theory:Solutions, PhaseEquilibria, Conductance, Electrochemistry, Transition Metal & Coordination Chemistry	4 Credit

Physical Chemistry – III

1. Solutions **(7L)**

a. Ideal solutions and Raoult's law, deviations from Raoult's law – non-ideal solutions; Vapour pressure-composition and temperature-composition curves of ideal and non-ideal solutions; Distillation of solutions; Lever rule; Azeotropes

b. Critical solution temperature; effect of impurity on partial miscibility of liquids; Immiscibility of liquids- Principle of steam distillation; Nernst distribution law and its applications, solvent extraction

2. Phase Equilibria **(7L)**

a. Phases, components and degrees of freedom of a system, criteria of phase equilibrium; Gibbs Phase Rule and its thermodynamic derivation; Derivation of Clausius – Clapeyron equation and its importance in phase equilibria; Phase diagrams of one-component systems (water and sulphur) and two component systems involving eutectics, congruent and incongruent melting points (lead-silver, $FeCl_3$-H_2O and Na-K only)

3. Conductance **(8L)**

a. Conductance, cell constant, specific conductance and molar conductance; Variation of specific and equivalent conductance with dilution for strong and weak electrolytes; Kohlrausch's law of independent migration of ions; Equivalent and molar conductance at infinite dilution and their determination for strong and weak electrolytes; Ostwald's dilution law; Application of conductance measurement (determination of solubility product and ionic product of water); Conductometric titrations (acid-base)

b. Transport Number and principles of Hittorf's and Moving-boundary method

4. Electromotive force **(8L)**

a. Faraday's laws of electrolysis, rules of oxidation/reduction of ions based on half-cell potentials, applications of electrolysis in metallurgy and industry; Chemical cells, reversible and irreversible cells with examples; Electromotive force of a cell and its measurement, Nernst equation; Standard electrode (reduction) potential; Electrochemical series; Thermodynamics of a reversible cell, calculation of thermodynamic properties: G, H and S from EMF data

b. Concentration cells with and without transference, liquid junction potential; pH determination using hydrogen electrode and quinhydrone; Qualitative discussion of potentiometric titrations (acid-base, redox, precipitation)

Inorganic Chemistry - III

1. Transition Elements (3d series) **(10L)**

a. General group trends with special reference to electronic configuration, variable valency, colour, magnetic and catalytic properties, ability to form complexes and stability of various oxidation states (Latimer diagrams) for Mn, Fe and Cu.

b. Lanthanoids and actinoids: Electronic configurations, oxidation states, colour, magnetic properties, lanthanide contraction, separation of lanthanides (ion exchange method only).

2. Coordination Chemistry **(10L)**

a. Werner's coordination theory, Valence Bond Theory (VBT): Inner and outer orbital complexes of Cr, Fe, Co, Ni and Cu (coordination numbers 4 and 6). Structural and stereoisomerism in complexes with coordination numbers 4 and 6.

b. Drawbacks of VBT. IUPAC system of nomenclature.

3. Crystal Field Theory (CFT) **(10L)**

a. Postulates of CFT, splitting of d-orbitals in octahedral and tetrahedral fields, Crystal field stabilization energy (CFSE), Crystal field effects for weak and strong fields. Factors affecting the magnitude of Δ. Spectrochemical series. Comparison of CFSE for O_h and T_d complexes, Tetragonal distortion of octahedral geometry.

b. Jahn-Teller distortion

Reference Books

1. Barrow, G.M. Physical Chemistry Tata McGraw-Hill (2007). 2. Castellan, G.W. Physical Chemistry 4th Ed. Narosa (2004). 3. Kotz, J.C., Treichel, P.M. & Townsend, J.R. General Chemistry Cengage Learning India Pvt. Ltd., New Delhi (2009). 4. Mahan, B.H. University Chemistry 3rd Ed. Narosa (1998). 5. Petrucci, R.H. General Chemistry 5th Ed. Macmillan Publishing Co.: New York (1985). 6. Chugh, K.L., Agnish, S.L. A Text Book of Physical Chemistry Kalyani Publishers. 7. Bahl, B.S., Bahl, A., Tuli, G.D., Essentials of Physical Chemistry S. Chand & Co. ltd. 8. Palit, S. R., Elementary Physical Chemistry Book Syndicate Pvt. Ltd. 9. Pahari, S., Physical Chemistry New Central Book Agency. 10. Pahari, S., Pahari, D., Problems in Physical Chemistry New Central Book Agency. Cotton, F.A. & Wilkinson, G. Basic Inorganic Chemistry, Wiley. 11. Shriver, D.F. & Atkins, P.W. Inorganic Chemistry, Oxford University Press. 12. Wulfsberg, G. Inorganic Chemistry, Viva Books Pvt. Ltd. 13. Rodgers, G.E. Inorganic & Solid State Chemistry, Cengage Learning India Ltd., 2008.

CHEMGP-4	Practical	2 Credit

Physical Chemistry - III

(Minimum six experiments to complete)

1. Distribution Law (Any one)

a. Study of the equilibrium of one of the following reactions by the distribution method:

$I_2(aq) + I^-(aq) = I_3^-(aq)$

2. Conductance

a. Determination of dissociation constant of a weak acid (cell constant, equivalent conductance are also determined)

b. Perform the following conductometric titrations: (Any one)

i. Strong acid vs. strong base

ii. Weak acid vs. strong base

3. Potentiometry

a. Perform the following potentiometric titrations:

i. Weak acid vs. strong base

ii. Potassium dichromate vs. Mohr's salt

Inorganic Chemistry – III

1. Complexometric estimation of (i) Mg^{2+} or (ii) Zn^{2+} using EDTA.
2. Preparation of any two of the following complexes:

a. tetraamminecarbonatocobalt (III) nitrate

b. tetraamminecopper(II) sulphate

c. potassium trioxalatochromate(III) trihydrate

d. potassium bisoxalatocuprate(II) trihydrate

Semester - V

CHEMGTDSE-1	Theory: Analytical, Environmental and Industrial Chemistry	4 Credit

Analytical and Environmental Chemistry

1. Chemical Analysis **(14L)**

a. Gravimetric analysis: solubility product and common ion effect; requirements of gravimetry; gravimetric estimation of chloride, sulphate, lead, barium, nickel, copper and zinc.

b. Volumetric analysis: primary and secondary standard substances; principles of acid-base, oxidation –reduction and complexometric titrations; indicators: acid-base, redox and metal ion; principles of estimation of mixtures: $NaHCO_3$ and Na_2CO_3 (by acidimetry); iron, copper, manganese and chromium (by redox titration); zinc, aluminum, calcium and magnesium (by complexometric EDTA titration).

c. Chromatography: Chromatographic methods of analysis: column chromatography and thin layer chromatography.

2. Environmental Chemistry **(16L)**

a. The Atmosphere: composition and structure of the atmosphere; troposphere, stratosphere, mesosphere and thermosphere; ozone layer and its role; major air pollutants: CO, SO_2, NO_x and particulate matters – their origin and harmful effects; problem of ozone layer depletion; green house effect; acid rain and photochemical smog; air pollution episodes: air quality standard; air pollution control measures: cyclone collector, electrostatic precipitator, catalytic converter.

b. The Hydrosphere: environmental role of water, natural water sources, water treatment for industrial, domestic and laboratory uses; water pollutants; action of soaps and detergents, phosphates, industrial effluents, agricultural runoff, domestic wastes; thermal pollution, radioactive pollution and their effects on animal and plant life; water pollution episodes: water pollution control measures : waste water treatment; chemical treatment and microbial treatment; water quality standards: DO, BOD, COD, TDS and hardness parameters; desalination of sea water : reverse osmosis, electrodialysis.

c. The Lithosphere: water and air in soil, waste matters and pollutants in soil, waste classification, treatment and disposal; soil pollution and control measures.

Analytical Industrial Chemistry

1. Error Analysis and Computer Applications **(12L)**

a. Error analysis: accuracy and precision of quantitative analysis, determinate, indeterminate, systematic and random errors; methods of least squares and standard deviations.

b. Computer applications: general introduction to computers, different components of a computer; hardware and software; input and output devices; binary numbers and arithmetic; introduction to computer languages; programming and operating systems.

2. Industrial Chemistry **(18L)**

a. Fuels: classification of fuel; heating values; origin of coal, carbonization of coal, coal gas, producer gas, water gas, coal based chemicals; origin and composition of petroleum, petroleum refining, cracking, knocking, octane number, antiknock compounds, kerosene, liquefied petroleum gas (LPG), liquefied natural gas (LNG); petrochemicals (C1 to C3 compounds and their uses).

b. Fertilizers: manufacture of ammonia and ammonium salts, urea, superphosphate, biofertilizers.

c. Glass and ceramics: definition and manufacture of glasses, optical glass and coloured glass; clay and feldspar, glazing and vitrification, glazed porcelein, enamel.

d. Cement: portland cement: composition and setting of cement, white cement.

Reference Books

1. Banerjee, S. P. A Text Book of Analytical Chemistry, The New Book Stall. 2. Gangopadhyay, P. K. Application Oriented Chemistry, Book Syndicate. 3. Mondal, A. K & Mondal, S. Degree Applied Chemistry, Sreedhar Publications. 4. Banerjee, S. P. A Text Book of Analytical Chemistry, The New Book Stall. 5. Gangopadhyay, P. K. Application Oriented Chemistry, Book Syndicate. 6. Mondal, A. K & Mondal, S. Degree Applied Chemistry,

Sreedhar Publications. 7. Banerjee, S. P. A Text Book of Analytical Chemistry, The New Book Stall.

CHEMGPDSE-1	Practical	2 Credit

Analytical and Environmental Chemistry

1. To find the total hardness of water by EDTA titration.
2. To find the pH of an unknown solution by comparing color of a series of HCl solutions + 1 drop of methyl orange, and a similar series of NaOH solutions + 1 drop of phenolphthalein.
3. To determine the rate constant for the acid catalysed hydrolysis of an ester.
4. Determination of the strength of the H_2O_2 sample.
5. To determine the solubility of a sparingly soluble salt, e.g. KHTa (one bottle)

Analytical and Industrial Chemistry

1. Titration of Na_2CO_3 and $NaHCO_3$ mixture vs HCl using phenolphthalein and methyl orange indicators.
2. Titration of HCl and CH_3COOH mixture vs NaOH using two different indicators to find the concentration.
3. Estimation of available oxygen in pyrolusite

Reference Books

1. University Hand Book of Undergraduate Chemistry Experiments, edited by Mukherjee, G. N. University of Calcutta, 2003. 2. Das, S. C., Chakraborty, S. B., Practical Chemistry. 3. University Hand Book of Undergraduate Chemistry Experiments, edited by Mukherjee, G. N. University of Calcutta, 2003. 4. Das, S. C., Chakraborty, S. B., Practical Chemistry. 5. Ghosal, Mahapatra & Nad, An Advanced Course in Practical Chemistry, New Central Book Agency.

Semester - VI

CHEMGTDSE-2	Theory: Advanced Organic Chemistry and Industrial Chemistry	4 Credit

Advanced Organic Chemistry

Functional group approach for the following reactions (preparations & reactions) to be studied in context to their structures.

1. **Carboxylic Acids and Their Derivatives** **(10L)**

a. Carboxylic acids (aliphatic and aromatic): strength of organic acids: comparative study with emphasis on factors affecting pK values; Preparation: acidic and alkaline hydrolysis of esters ($B_{AC}2$ and $A_{AC}2$ mechanisms only) and from Grignard reagents; Reactions: Hell - Vohlard - Zelinsky reaction and Claisen condensation; Perkin reaction.

b. Carboxylic acid derivatives (aliphatic): (up to 5 carbons). Preparation: acid chlorides, anhydrides, asters and amides from acids; Reactions: Comparative study of nucleophilicity of acyl derivatives; interconversion among acid derivatives.

2. Amines and Diazonium Salts **(10L)**

a. Amines (aliphatic and aromatic): strength of organic bases; Preparation: from alkyl halides, Gabriel's phthalimide synthesis, Hofmann degradation, by reduction of nitro compounds; Reactions: with HNO_2 (distinction of 1°-, 2°- and 3°- amines), Schotten – Baumann reaction , Diazo coupling reaction (with mechanism).

b. Diazonium salts: Preparation: from aromatic amines; Reactions: conversion to benzene, phenol, benzoic acid and nitrobenzene.

c. Nitro compounds (aromatic): reduction under different conditions (acidic, neutral and alkaline).

3. Amino Acids and Carbohydrates **(10L)**

a. Amino Acids: Preparations (glycine and alanine only): Strecker synthesis, Gabriel's phthalimide synthesis; general properties; zwitterion, isoelectric point; ninhydrin reaction.

b. Carbohydrates: classification and general properties; glucose and fructose: constitution; osazone formation; oxidation-reduction reactions; epimers of glucose (definition and example

only); cyclic structures of glucose (determination of ring-size excluded); ascending (Kiliani – Fischer method) and descending (Ruff's and Wohl's methods) in monosaccharides (aldoses only); mutarotation.

Industrial Chemistry

1. Polymers: **(4L)**

Basic concept, structure and types of plastics, polythene, polystyrene, phenolformaldehydes, PVC; manufacture, physical properties and uses of natural rubber, synthetic rubber, silicone rubber; synthetic fibres, nylon-66, polyester, terylene, rayon; foaming agents, plasticizers and stabilizers.

2. Paints: **(3L)**

Primary constituents; formulation of paints; binders and solvents for paints; oil based paints, latex paints, alkyd resin paint.

3. Varnishes: **(2L)**

Constituents of varnishes; formulation of varnishes.

4. Synthetic dyes: **(2L)**

Synthesis of methyl orange, congo red, malachite green, crystal violet.

5. Drugs and pharmaceuticals: **(3L)**

Concept and necessity of drugs and pharmaceuticals; preparation and uses: aspirin, paracetamol, sulphadiazine, quinine, chloroquine, phenobarbital, metronidazole.

6. Fermentation chemicals: **(3L)**

Production and purification of ethyl alcohol, citric acid, lactic acid, vitamin B12, penicillin. Industrial Chemistry.

7. Fats and oils: **(3L)**

Natural fat, edible and inedible oil of vegetable origin; common fatty acids; glycerides; hydrogenation of unsaturated oil, production of vanaspati and margarine.

8. Soaps and detergents: **(3L)**

Production of toilet and washing soaps; enzyme-based detergents, detergent powder; liquid soaps.

9. Pesticides: **(3L)**

Common pesticides: production, applications and residual toxicity of gammaxane, aldrin, parathion, malathion, DDT, paraquat, decamethrin.

10. Food additives: **(4L)**

Food flavour, food colour, food preservatives, artificial sweeteners, acidulants, alkalies, edible emulsifiers and edible foaming agents, sequesterants – uses and abuses of these substances in food beverages.

Reference Books

1. Sethi, A. Conceptual Organic Chemistry; New Age International Publisher. 2. Parmar, V. S. A Text Book of Organic Chemistry, S. Chand & Sons. 3. Madan, R. L. Organic Chemistry, S. Chand & Sons. 4. Ekambaram, S. General Chemistry, Pearson. 5. Wade, L. G., Singh, M. S., Organic Chemistry. 6. Finar, I. L. Organic Chemistry (Volume 1), Dorling Kindersley (India) Pvt. Ltd.(Pearson Education). 7. Morrison, R. T. & Boyd, R. N. Organic Chemistry, Dorling Kindersley (India) Pvt.Ltd. (Pearson Education). 8. Bahl, A. & Bahl, B.S. Advanced Organic Chemistry, S. Chand, 2010. 9. Gangopadhyay, P. K. Application Oriented Chemistry, Book Syndicate. 10. Mondal, A. K & Mondal, S. Degree Applied Chemistry, Sreedhar Publications. 11. Banerjee, S. P. A Text Book of Analytical Chemistry,The New Book Stall.

CHEMGPDSE-2	**Practical:**	**2 Credit**

Advanced Organic Chemistry

1. The following reactions are to be performed, noting the yield of the crude product:

a. Nitration of aromatic compounds

b. Condensation reactions

c. Hydrolysis of amides/imides

d. Acetylation of aromatic amines
e. Benzoylation of aromatic amines

2. Purification of the crude product is to be made by crystallisation from water/alcohol.

Industrial Chemistry

1. Estimation of saponification value of oil / ester / fat.
2. Estimation of available chlorine in bleaching powder.
3. Estimation of acetic acid in commercial vinegar.
4. Estimation of amino acid by formol titration

Reference Books

1. Vogel, A. I. Elementary Practical Organic Chemistry, Part 1: Small scale Preparations, CBS Publishers and Distributors. 2. University Hand Book of Undergraduate Chemistry Experiments, edited by Mukherjee, G. N., University of Calcutta, 2003. 3. Mann, F.G. & Saunders, B.C. Practical Organic Chemistry, Pearson education. 4. Furniss, B.S., Hannaford, A.J., Smith, P.W.G. & Tatchell, A.R. Practical Organic Chemistry, 5th Ed. Pearson (2012). 5. Ahluwalia, V.K. & Aggarwal, R. Comprehensive Practical Organic Chemistry: Preparation and Quantitative Analysis, University Press (2000). 6. Practical Workbook Chemistry (Honours), UGBS, Chemistry, University of Calcutta, 2015. 7. Arthur, I. V. Quantitative Organic Analysis, Pearson. 8. Das, S. C., Chakraborty, S. B., Practical Chemistry. 9. Ghosal, Mahapatra & Nad, An Advanced Course in Practical Chemistry, New Central Book Agency.